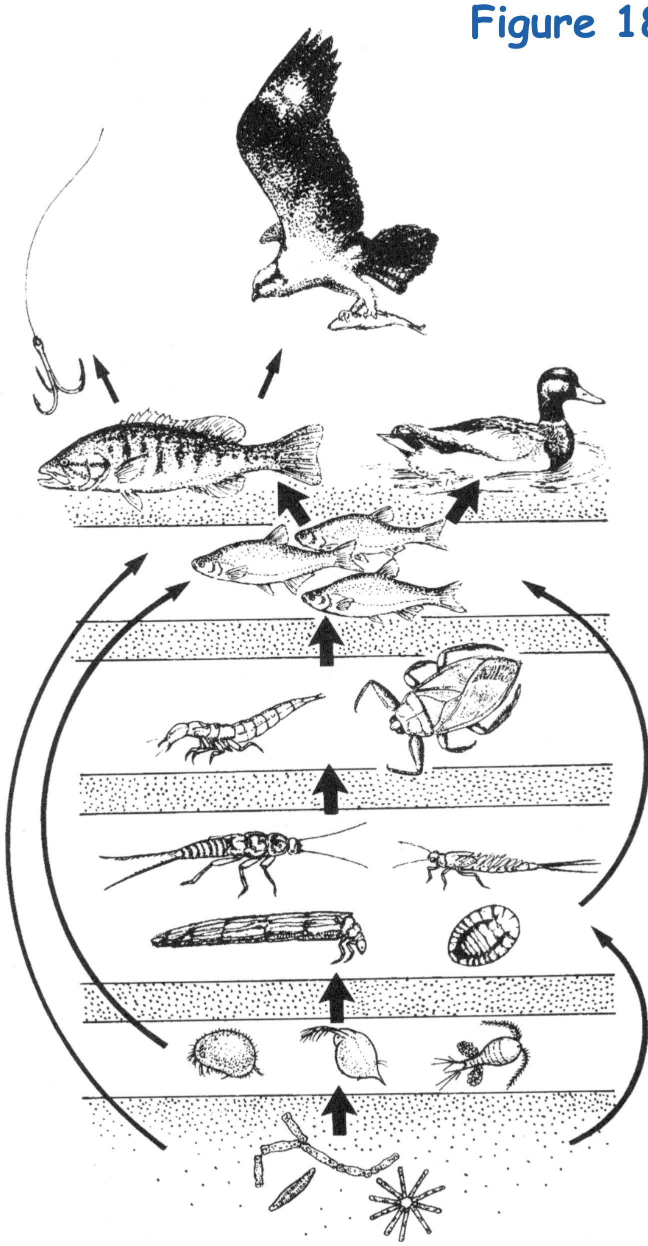
Figure 18



from Pond & Stream Safari, Cornell Cooperative Extension

Aquatic Food Web

What is the ecological importance of benthic macroinvertebrates? Benthos are an important part of the food chain, especially for fish. Many feed on algae and bacteria which are on the lower end of the food chain. Some shred and eat leaves and other organic matter that enters the water. Because of their abundance and position as "middleman" in the aquatic food chain, benthos play a critical role in the balance and natural flow of energy and nutrients. As benthos die, they decay, leaving behind nutrients that are reused by aquatic plants and other animals in the food chain.

(Source: Maryland Dept of Natural Resources)

Benthic Macroinvertebrates

Benthic macroinvertebrates are animals that are big enough (macro) to be seen with the naked eye. They lack backbones (invertebrate) and live at least part of their lives in or on the bottom (benthos) of a body of water.

Macroinvertebrates include aquatic insects (such as mayflies, stoneflies, caddisflies, midges, beetles), snails, worms, freshwater clams, mussels, and crayfish. Some benthic macroinvertebrates, such as midges, are small and grow no larger than 1/2 inches in length. Others, like the three ridge mussel, can be over ten inches long.

Why Do We Monitor Them?

Biological monitoring focuses on the aquatic organisms that live in streams and rivers. Scientists observe changes that occur in the number of types of organisms present in a stream system to determine the richness of the biological community. They also observe the total number of organisms in an area, or the density of the community. If community richness and community density change over time, it may indicate the effects of human activity on the stream.

Biological stream monitoring is based on the fact that different species react to pollution in different ways. Pollution-sensitive organisms such as mayflies, stoneflies, and caddisflies are more susceptible to the effects of physical or chemical changes in a stream than other organisms. These organisms act as indicators of the absence of pollutants. Pollution-tolerant organisms such as midges and worms are less susceptible to changes in physical and chemical parameters in a stream. The presence or absence of such indicator organisms is an indirect measure of pollution. When a stream becomes polluted, pollution-sensitive organisms decrease in number or disappear; pollution-tolerant organisms increase in variety and number.

In addition to being sensitive to changes in the stream's overall ecological integrity, benthic macroinvertebrates offer other advantages to scientists looking for indications of stream pollution.

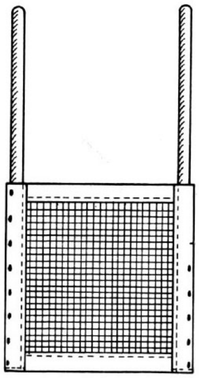
- Benthic macroinvertebrates are relatively easy to sample. They are abundant and can be easily collected and identified by trained volunteers.

  They are relatively immobile. Fish can escape toxic spills or degraded habitats by swimming away. Migratory animals may spend only a small portion of their life cycles in a particular stream before moving to larger rivers, wetlands, or other streams. However, most macroinvertebrates spend a large part of their life cycle in the same part of a stream, clinging to objects so they are not swept away with the water's current.

- Benthic macroinvertebrates are continuous indicators of environmental quality. The composition of a macroinvertebrate community in a stream reflects that stream's physical and chemical conditions over time. Monitoring for certain water quality parameters (such as the amount of dissolved oxygen) only describes the condition of the water at the moment in time the samples were taken.

- Benthic macroinvertebrates are a critical part of the aquatic food web (See Figure 18 on adjacent page). They form a vital link in the food chain connecting aquatic plants, algae, and leaf litter to the fish species in streams. The condition of the benthic macroinvertebrate community reflects the stability and diversity of the larger aquatic food web.

How Do We Collect Them?



Kick Seine Sampling Method

The kick seine method is a simple procedure for collecting stream-dwelling macroinvertebrates. It is used in riffle areas where the majority of the organisms prefer to live. This method can be quite effective in determining relative stream health; **however, it is only as good as the sampling technique.** Two to three people work together to perform the method properly. Carefully read the procedures, and follow them as closely as possible.

1. Locate a "typical riffle." Such a riffle is a shallow, faster moving mud-free section of stream with a stream bed composed of material ranging in size from one-quarter inch gravel or sand to ten-inch cobbles. The water ranges in depth from approximately two inches to a foot, with a moderately swift flow. Avoid riffles located in an area of a stream that has been recently disturbed by anything, including construction of a pipeline crossing or roadway.
2. Once the riffle has been located, select an area measuring 3 feet by 3 feet that is typical of the riffle as a whole. Avoid disturbing the stream bed upstream from this area.
3. Examine the net closely and remove any organisms remaining from the last time it was used.
4. **Approach the sampling area from downstream!**
5. Have one person place the net at the downstream edge of the sampling area. (It may take two people to hold it in place.) The net should be held perpendicular to the flow, but at a slight (45 degree) downstream angle. Stretch the net approximately three feet, being certain that the bottom edge is lying firmly against the bed. If water washes beneath or over the net you will lose organisms.
6. Another person comes upstream of the net. **Stand beside, not within the sampling area.** Remove all stones and other objects two inches or more in diameter from the sampling area. Hold each one below the water as you brush all organisms from the rock into the net. You can also place rocks on the bottom edge of the net to help hold it in place against the stream bottom.
7. When all materials two inches or larger have been brushed, step into the upstream edge of the sampling area 3 feet from the net and kick the stream bed vigorously until you have disturbed the entire sampling area. Kick from the upstream edge toward the net. Try to disturb the bed to a depth of at least two inches. You can also use a small shovel to disturb the bed. Kick for approx. 3 minutes.
8. Carefully remove the net with a forward upstream scooping motion. DO NOT allow water to flow over the top of the net or you may lose organisms.
9. Carry the seine to a flat area on the stream bank. Place it on a large white sheet, plastic table cloth, garbage bag, or shower curtain. Remove leaves, rocks, and other debris - examine them for any attached organisms. Using fingers or forceps, remove organisms from the net and place in another container with water for later identification. If nothing appears to be on the net, leave it alone for a few minutes, and the organisms will begin to move around because they are out of the water. Be sure to check your white ground cover for any creatures attempting to escape. If you happen to collect live mussels (native or exotic) in your net, please see page 69 for further instruction.
10. Perform steps 1-9 a total of three times at different locations within your 200' site. Your goal is to collect 200 at least organisms.
11. Sort all the organisms collected from the three samples according to body shape using ice cube trays or petri dishes. Record the number of each type of organism (if more than 100; record >100).

Dip Net Sampling Method

If there are no riffles at your stream site to perform the kick seine sampling method, then you should use the dip net to perform your biological monitoring. Take a total of <u>twenty jabs</u> in a variety of habitats (See Figures 19 & 20). One dip net "jab" involves forcing the dip net against the stream bottom repeatedly, starting close to your body and finishing with arms fully outstretched. However, sampling technique differs depending on habitat conditions. *(Modified from the Clinton River Watershed Teacher Training Manual)*

- **Leaf Pack**: Shake the leaf pack in the water to release organisms, and then quickly scoop up the net, capturing both the organisms and the leaves. (See information on the next page for experiments using leaf packs.)
- **Tree Roots, Snags (accumulations of debris), and Submerged Logs:** Select an area approximately 3 by 3 feet in size. Scrape the surface of roots, logs, or debris with the net, a large stick, or your hand or foot. Be sure the net is positioned downstream so that dislodged material floats into it.
- **Undercut Banks (see picture on page 22):** Place the net below the overhanging vegetation. Move the net in a bottom-up motion, jabbing at the bank several times to loosen organisms.
- **Sediments** (sand/mud): If there is not much flow, jab the net into the bottom with a sweeping motion. If flow is good, stand upstream of the net holding it against the bottom of the stream and kick in front of the net so that the flow washes organisms into the net. To rinse, keep the opening of the net at least 1-2 inches above the surface of the water, and move it back and forth to wash small particles out of the net.

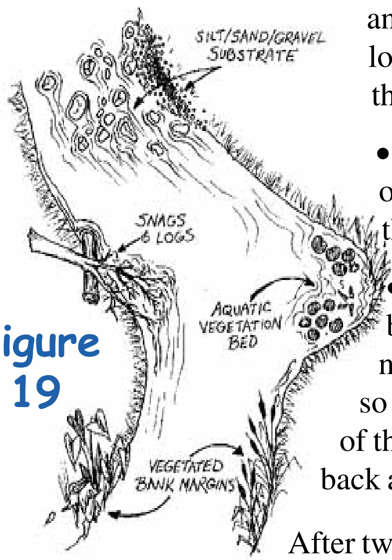


Figure 19

After two or three jabs with one net, dump the collected materials into a shallow white container (a dishpan works well). The materials in the bin may be quite muddy and turbid (depending upon your stream habitat). When you find macroinvertebrates, place them into another container (white pan, petri dish, bug board, ice cube tray) with clear water for easier identification.

Combination Sampling Method

If your 200' site has a variety of habitats, including riffles, then you may perform a **combination** of sampling methods. Record the equipment used and the types of habitats sampled on the Biological Monitoring Data Sheet (page 91).

Macroinvertebrate Reporting & Analysis

This three-star quality rating was developed to give you an idea of where your data ranks in terms of quality assurance. The more stars you get the better. It is important to note that ALL volunteer data is useful (including one-star results). We do not ask you to report your quality level; this information is provided to help you develop your monitoring plan. It is preferable to count the macroinvertebrates collected, spend at least 45 minutes collecting and identifying, and to collect at least 200 organisms.

★ Noting the presence of organisms (not counting them) and/or spending less than 45 minutes
★★ Counting the actual # of macroinvertebrates collected and spending more than 45 minutes
★★★ Counting the actual # of macroinvertebrates (at least 200 collected) and spending > 45 minutes

Where to Sample

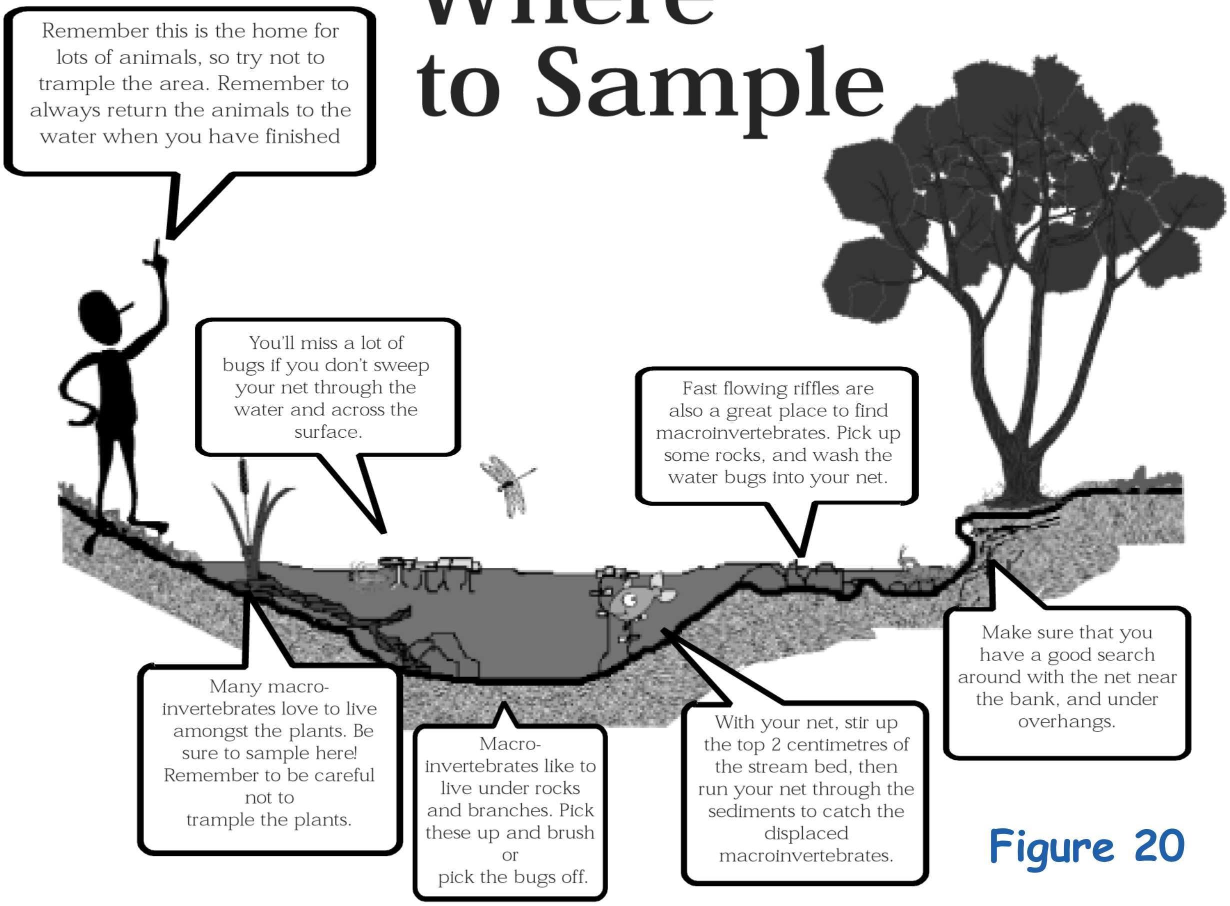


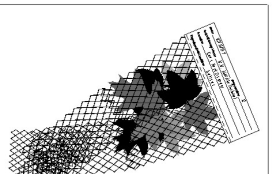
Figure 20

reprinted with permission from the South Australia Water Watch

Leaf Pack Experiments or Hester-Dendy Samplers

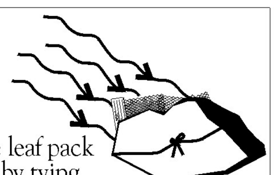
Another type of sampling involves placing an artificial substrate in the stream for a number of weeks, then collecting it after it's been colonized by macroinvertebrates. These methods are useful if you are sampling a deep river and use of a net is difficult, or if you do not have sufficient time at the stream to perform the proper kick seine or dip net sampling procedures. Instructions for making your own Hester-Dendy are provided in Appendix A. Leaf pack experiments (below) are flexible; however, each experiment will (1) provide an understanding of the structure and function of macroinvertebrates within a stream community, and (2) relate the abundance and variety of macroinvertebrates colonizing artificial leaf packs to: habitat quality, water quality, and the influence of the forested riparian area.

1



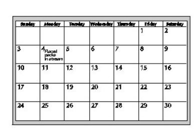
Fill a mesh bag (5882-LPB) with local leaves or plant material to create a leaf pack.Tie a knot to close the bag.

2



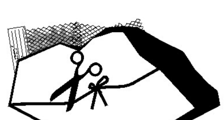
Anchor the leaf pack in the river by tying it to the upstream side of a rock or cinder block.

3



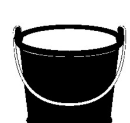
Leave the leaf pack in place for 3-4 weeks.

4



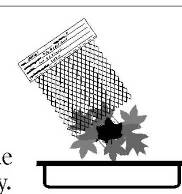
When removing the leaf pack from the river, care should be taken to disturb the leaf pack as little as possible. Approach the leaf pack from downstream and place a bucket or net under it to catch organisms that may be dislodged.

5



Place the leaf pack in a bucket partially filled with water to carry it to the sorting area.

6



Carefully transfer the contents of the bag to a white tray. Also transfer any organisms remaining in the bucket to the tray.

How Do They Develop?

Many of the benthic macroinvertebrates you will encounter are aquatic insects. Aquatic insects have complex life cycles and live in the water only during certain stages of development (See Figure 21).

Complete Metamorphosis

Aquatic insects may go through one of two kinds of development or metamorphosis. Those that go through complete metamorphosis undergo four stages of development: egg, larva, pupa, and adult. They lay their eggs in water; eggs then hatch into larvae that feed and grow in the water. (These larval insects do not resemble the adult insects; many appear wormlike.) The fully-grown larvae develop into pupae and then into adults. The fully-formed adults of some species (midges and flies, for example) emerge from the water and live in the habitat surrounding the stream. Others, such as riffle beetles, continue to live in the stream as adults. After mating, adults of all aquatic insect species lay eggs in the water, beginning the life-cycle all over again.

Complete metamorphosis: egg → larvae → pupa → adult
(true flies, beetles, caddisflies)

Incomplete Metamorphosis

Aquatic insects that go through incomplete metamorphosis undergo only three stages of development; eggs, nymphs and adult. The eggs hatch into nymphs which feed and grow in the water while they develop adult structures and organs. (Nymphs often look similar in body shape to the adults.) The life cycle begins again when adults lay eggs in the water.

Incomplete metamorphosis: egg → nymph → adult
(mayflies, dragonflies, stoneflies, true bugs)

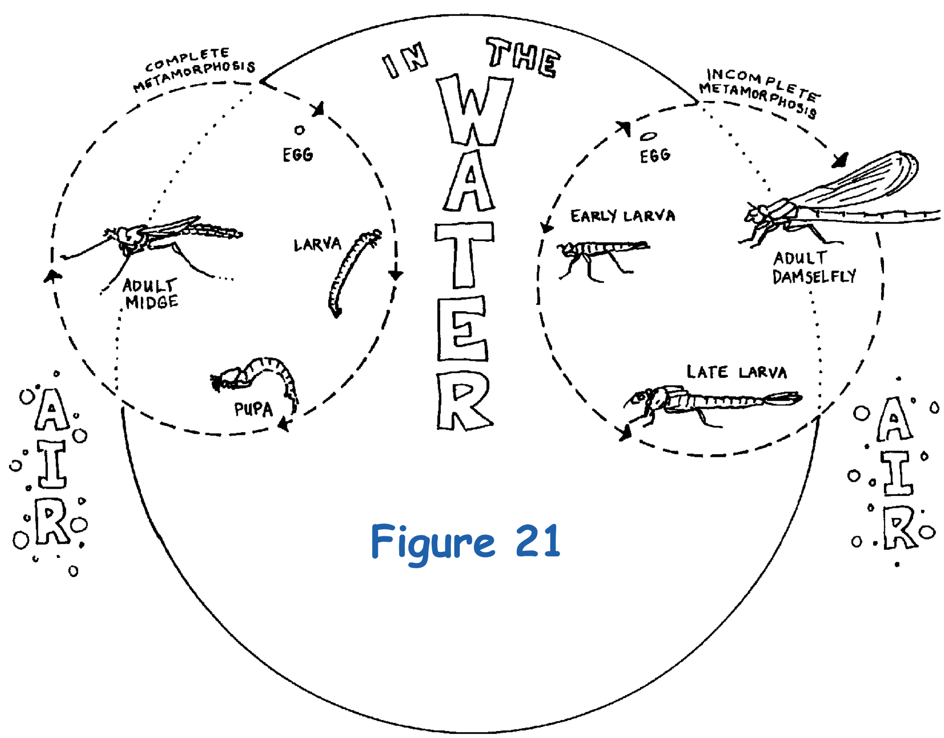


Figure 21

What and How Do They Eat?

Macroinvertebrates may be categorized by their feeding groups - the type of food they eat and the manner in which food is obtained/collected.

Shredder: feeds on coarse, dead organic matter (leaves, grasses, algae, and rooted aquatic plants), breaking it into finer material that is released in their feces. Shredders include stonefly nymphs, caddisfly larvae, cranefly larvae.

Collector: feeds on fine, dead organic matter, including that produced by the shredders.

Filtering collector: filters particles out of flowing current. Examples include blackfly larvae and net-building caddisflies.

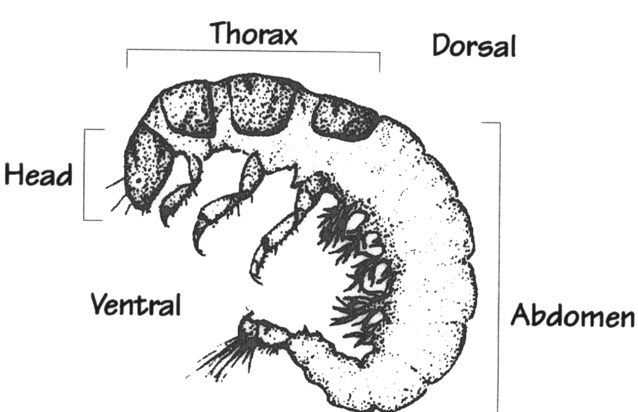
Gathering collector: gathers matter while crawling along the river bottom. Gatherers include mayfly nymphs, adult beetles, midge larvae.

Grazer: grazes on algae growing on rocks in the substrate or on vegetation. Grazers include snails and water pennies.

Predator: feeds on other invertebrates or small fish. Mouth parts are specially adapted to feed on prey. Dragonflies and damselflies have scoop-like lower jaws, the jaws of hellgrammites (dobsonflies) are pincher-like, and water strider's mouth parts are spear-like. Also includes beetle adults and larvae.

What Do They Look Like?

A simple key to benthic macroinvertebrates is provided on the following pages. The organisms are grouped according to pollution tolerance, starting with the most intolerant families. Figure 22 below (from the GREEN Standard Water Monitoring Kit) may help you identify the distinguishing features of many of the organisms.



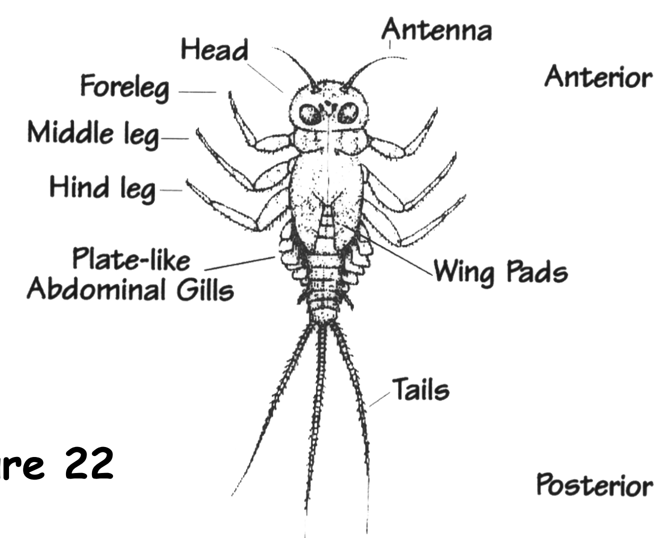


Figure 22

What If You Find Freshwater Mussels?

Freshwater mussels are the **most endangered group of animals** in Indiana! Of the 77 species that once inhabited Hoosier lakes, rivers and streams, 10 are now extinct, 15 are endangered, and 9 are of special concern. As the presence and diversity of freshwater mussels serve as an indicator of river and stream health, we must minimize our impact on the stream substrate to protect these important species.

Follow these guidelines:

- **AVOID** sampling (especially kick seining) where you observe live mussels or a bed of mussel shells (open or closed).
- If you happen to collect mussels when sampling for macroinvertebrates**, you *MUST* replace ALL** mussels in the stream in the exact location and orientation where you found them. Observe any live mussel's shell for clues to its original orientation. If part of the mussel is covered in algae and part in mud, the algae side was sticking up toward the sun while the other side was buried in the substrate. Also, the hinge (closure) should face downstream, with the opening toward the streamflow.
- Be careful not to spread exotic species. Volunteers sampling in **zebra mussel** infested waters should **allow their equipment to dry completely** before using it in another water body. Immature zebra mussel *veligers* can live for a while out of water. If the equipment must be used in a different waterbody soon after sampling in infested waters, you must rinse the equipment thoroughly with hot water!

Identifying mussel species is not an easy task; only specially-trained biologists are able to differentiate species. It's unlikely we, as volunteer stream monitors, will be able to distinguish an endangered mussel from a non-endangered species. Therefore, ***ALL*** mussels should be treated as though they are endangered!

Freshwater Mussels Regulations

In an effort to reverse statewide declines in their populations, the removal of freshwater mussels, both live specimens and dead shells, from Indiana waters became illegal in 1991. It is **illegal** to have live or dead mussel shells in your possession. (Live shells are closed and are held together by the living mussel inside.) Leaving the mussels in the streams not only protects them, but you as well!

Why are Freshwater Mussels in Danger?

Freshwater mussel populations have suffered because of **habitat disturbances** such as dam construction, channelization, dredging, and watershed activities such as construction and agriculture, which can lead to increased siltation and polluted runoff to rivers, streams, and lakes.

Commercial demands for freshwater mussel shells have also contributed to their decline. Mussel shells were used to make pearl buttons from the late 19th and early 20th centuries until the 1940s when plastic became the button material of choice. Current commercial use involves grinding freshwater mussel shells to insert into oysters and stimulate the production of cultured pearls. Poaching remains a threat to mussel populations. If you suspect poaching of mussels, report it to the Indiana Department of Natural Resources immediately through **1-800-TIP-IDNR.**

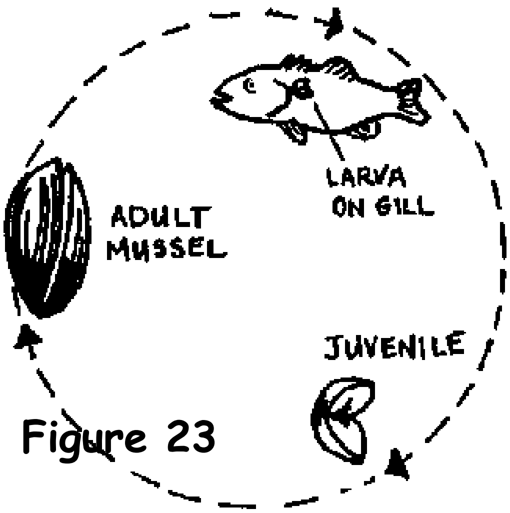


Figure 23

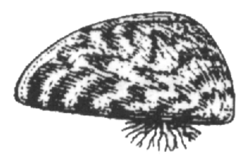
Life Cycle of Mussels

Mussels have a very complicated **life cycle** (Figure 23), which may make it difficult for some species to persist. Male mussels release their sperm into the water column, and the sperm must then be 'lucky' enough to be siphoned in by a female mussel downstream of the male (which is why it is **VERY** important that you **replace** a mussel exactly **where** and **how** you found it!). After a time, the female will release mussel larvae or *glochidia* into the water where they will die unless they attach to a host fish. The fish serves as a source of food, shelter and locomotion for the developing larvae. Without the proper fish to serve as host, many mussel species could not expand their ranges or survive!

Other Biological Indicators of Stream Health

Exotic Invasive Species

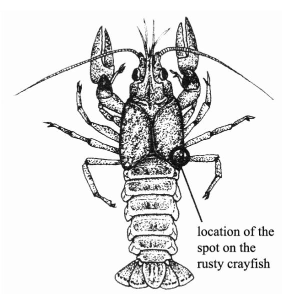
The introduction of **exotic invasive species** such as the Asian clam (*Corbicula fluminea*) and the very prolific zebra mussel (*Dreissena polymorpha*) has also had detrimental effects on many mussel species. If zebra mussels are found, check the box on the Biological Monitoring Data Sheet (page 95).



Zebra Mussel

Asiatic Clam

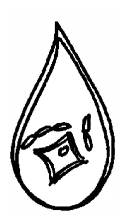
Rusty Crayfish



If your crayfish has a rusty spot on each side of its shell, it may be a species considered exotic in most of Indiana. This species causes problems because it overeats aquatic plants, takes over the homes of native crayfish, and sometimes it eats fish eggs. Fish don't like to eat it because it can be aggressive and feisty. (From *Wonderful Wacky Water Creatures,* UW-Extension.) If you find any rusty crayfish, don't put them back in the stream or river. Riverwatch is assisting with a research project, and we would like frozen specimen sent to us! Please visit our website for specific collection, documentation, and shipping instructions.

Aquatic Plants

Aquatic plants are indicators of clear water and stable substrate. They provide habitat and stabilize the stream bed during high flow conditions. They also produce oxygen and take contaminants out of the sediment via root absorption. (From *IOWATER Program Handbook*.)



% Algae Cover

Excess algae can be caused by too many nutrients in the stream. Too much algae can lead to oxygen depletion. Estimate the amount of the stream bottom (or the rocks) within your 200' stream section covered with algae - in increments of 25%, 50%, 75%, or 100%.

If any of these indicators are present, please check the appropriate box or % on the bottom of the Biological Monitoring Data Sheet (page 91).